1         1.     A storage system comprising:

2         a first computer system having a first storage component; and

3         a second computer system having a second storage component,

4         the first and second storage components configured to exchange data over

5 a data network,

6         the first computer system having a memory that is configured with

7 program code to write a block of data to the first storage component and to transmit a data

8 packet to the second computer system, the data packet including the block of data, a time

9 stamp, and a sequence number,

10         the second computer system having a memory that is configured with

11 program code to receive data packets from the first computer system, to select a candidate

12 data packet based on time stamps and sequence numbers contained in the data packets,

13 and to write the candidate data packet on the second storage system,

14         wherein blocks of data written on the first storage component are written

15 on the second storage component in the same order as on the first storage component.

1         2.     The system of claim 1 wherein the second memory is further

2 configured with program code to obtain a limit time stamp from among the time stamps

3 based on their corresponding sequence numbers and to select the candidate data packet

4 from among the data packets by comparing their corresponding time stamps against the

5 limit time stamp.

1         3.     The system of claim 1 wherein the data network is a connectionless

2 network.

1         4.     The system of claim 1 wherein the data network is characterized as

2 being unable to guarantee that data packets will be received in the same order as they

3 were sent.

1         5.     The system of claim 4 wherein the data network is a wide area

2 network.

1         6.     The system of claim 1 wherein the first storage component

2 comprises plural first data storage units, and the second storage component comprises

3    plural second data storage units, each of the first data storage units corresponding to one

4    of the second data storage units, wherein data stored on one of the first data storage units

5    is also stored on the corresponding second data storage unit.

1            7.    The system of claim 1 wherein the first storage component

2    comprises plural first disk systems and the second storage component comprises plural

3    second disk systems, each first disk system being associated with one or more of the

4    second disk systems, wherein data stored in one of the first disk systems is also stored on

5    the associated one or more of the second disk systems.

1            8.    The system of claim 7 wherein each of the first disk systems

2    comprises plural first disk units and each of the second disk systems comprises plural

3    second disk units, each of the first disk units being associated with one of the second disk

4    units.

1            9.    The system of claim 8 wherein each first disk unit is associated

2    with one of the second disk units independently of the first disk system to which the first

3    disk unit belongs.

1            10.    A method of backing up data contained in a local system to a

2    remote system, comprising:

3            writing a block of data to a local data store;

4            sending a data packet to the remote system, the data packet including the

5    block of data, a time stamp, and a sequence number;

6            receiving data packets from the local system; and

7            selecting a data packet whose block of data is to be written on a remote

8    data store, based on the sequence numbers and the time stamps of the data packets.

1            11.    The method of claim 10 further including incrementing the

2    sequence number for a next data packet.

1            12.    The method of claim 10 wherein selecting a data packet includes

2    'obtaining a limit time stamp from among the time stamps based on their associated

3    sequence numbers and selecting the data packet from among the data packets by

4    comparing their associated time stamps against the limit time stamp.

1    13.    The method of claim 10 wherein the local data store comprises
2 plural local disk units and the remote data store comprises plural remote disk units, each
3 local disk unit being paired with one of the remote disk units to define a remote copy pair.

1    14.    The method of claim 13 further including writing plural blocks of
2 data to the local disk units and sending plural data packets to the remote disk units so that
3 each remote disk unit has a list of sequence numbers from its associated plural data
4 packets, the method further including, for each list of sequence numbers, obtaining a
5 longest run of sequence numbers, obtaining the highest-valued sequence number from the
6 longest run, and obtaining the time stamp corresponding to the highest-valued sequence
7 number, thereby producing a list of time stamps, the method further including selecting a
8 data packet based on the earliest time stamp in the list of time stamps.

1    15.    The method of claim 10 wherein the local data store comprises
2 plural local disk systems and the remote data store comprises plural remote disk systems,
3 each local disk system being associated with one or more of the remote disk systems,
4 wherein data stored in one of the local disk systems is also stored on the associated one or
5 more of the remote disk systems.

1    16.    The method of claim 15 wherein each of the local disk systems
2 comprises plural local disk units and each of the remote disk systems comprises plural
3 remote disk units, each of the local disk units being associated with one of the remote
4 disk units.

1    17. 18.    The method of claim 16 wherein each local disk unit is associated
2 with one of the remote disk units independently of the local disk system to which the
3 local disk unit belongs.

1    18. 19.    The method of claim 10 wherein writing a block of data to a local
2 data store and sending a data packet to the remote system are performed asynchronously.

1    19. 20.    The method of claim 10 wherein the data packets are sent over a
2 connectionless data network.

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20 21. The method of claim 10 wherein the data packets are sent over a data network that is characterized as being unable to guarantee that data packets will arrive at a destination in the same order as they were sent.

21 22. The method of claim 21 wherein the data network is a wide area network.

22 23. In a local storage system comprising plural local data stores, a method for backing up data in the local storage system to a remote storage system comprising plural remote data stores, the method comprising:

each local data store, receiving a data block to be written thereto;

each local data store transmitting a data packet comprising the data block, a time stamp, and a sequence number to one of the remote data stores;

at the remote data stores, receiving plural data packets from the local data stores, wherein each remote data store has its associated plural data packets and a list of sequence numbers and a list of time stamps from the associated data packets;

at each remote data store, identifying a longest run of sequence numbers and obtaining the data packet of the highest-valued sequence number of the longest run;

at each remote data store, obtaining the earliest time stamp from the obtained data packet;

selecting the earliest of the obtained time stamps as a limit time;

at each remote data store, selecting a candidate data packet having the earliest time stamp; and

selecting the data packet from among the candidate data packets whose time stamp is earlier than the limit time.

23 24. The method of claim 23 wherein the local storage system comprises one or more local disk systems, each local disk system comprises one or more local disk drives, the remote storage system comprises one or more remote disk systems, and each remote disk system comprises one or more remote disk drives, each local disk drive being associated with one of the remote disk drives to define a remote copy pair.

24 25. The method of claim 24 wherein each local data store is one of the local disk drives and each remote data store is one of the remote disk drives, wherein there is a sequence number associated with each remote copy pair.

23

1      25 26.     The method of claim 25 wherein the received plural data packets

2   are grouped according to remote copy pair.

1      26 27.     The method of claim 24 wherein a sequence number is associated

2   with each pair of local and remote disk systems which have a common remote copy pair.

1      27 28.     The method of claim 27 wherein each of the plural data packets is

2   grouped based on the local disk system from which it was sent.

1      28 29.     The method of claim 24 wherein each remote copy pair is

2   associated with one of a plurality of data integrity pair groups, wherein a sequence

3   number is associated with each pair of local and remote disk systems which have a

4   common data integrity pair group.

1      29 30.     A data access method comprising:

2         providing a data transfer request, the data transfer request including a

3   sequence number;

4         transmitting the data transfer request from a local system to a remote

5   system;

6         at the remote system, providing a queue of entries containing blocks of

7   data, the data transfer request being directed to a target entry in the queue;

8         at the remote system, comparing the sequence number in the data transfer

9   request against the current value of a sequence number counter;

10        if the sequence number is not equal to the sequence number counter, then

11   gaining access to the target entry in the queue by traversing the queue by a number of

12   entries based on a difference between the sequence number and the sequence number

13   counter;

14        if the sequence number is equal to the sequence number counter, then

15   accessing one end of the queue to gain access to the target entry; and

16        executing the data transfer request on the target entry.

1      30 31.     The method of claim 30 wherein the remote system includes a

2   magnetic tape storage system and the data transfer requests are read and write requests to

3   the magnetic tape storage system.

1       31 ~~32.~~     The method of claim 30 wherein the data transfer request is a read

2  request and the blocks of data in the queue are used to satisfy the read request.

1       32 ~~33.~~     The method of claim 30 wherein the data transfer request is a write

2  request which includes write data to be inserted into the queue as a new entry, the new

3  entry being inserted before or after the target entry.